U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject:	The Certification of Aircraft Electrical and Electronic Systems for Operation in the High Intensity Radiated Fields (HIRF) Environment	**Date:** XX/XX/00 **Initiated by:** XXX-XXX	**AC No:** 20-xxx **Change:**

1. PURPOSE. This advisory circular (AC) provides information and guidance concerning an acceptable means, but not the only means, of showing compliance with Title 14, Code of Federal Regulations (14 CFR) §§ 23.1308, 25.1317, 27.1317, and 29.1317, regarding the operation of electrical and electronic systems on an aircraft when the aircraft is exposed to an external high intensity radiated fields (HIRF) environment. This AC is not mandatory nor does it constitute a regulation; an applicant may elect an alternative means of compliance acceptable to the Federal Aviation Administration (FAA).

2. FOCUS. This AC applies to all applicants seeking issuance of a type certificate (TC), an amended type certificate (amended TC), or a supplemental type certificate (STC) under Parts 23, 25, 27, and 29 for the initial approval of a new type of aircraft, a change in an aircraft type design, or the use of an existing piece of equipment or system on an aircraft that previously has not used that equipment or system.

3. RELATED MATERIAL.

a. Sections 23.901, 25.901, 27.901, and 29.901, Installation; §§ 23.903, 25.903, 27.903, and 29.903, Engines; §§ 23.1301, 25.1301, 27.1301, and 29.1301, Function and Installation; §§ 23.1309, 25.1309, 27.1309, and 29.1309, Equipment, Systems, and Installations; §§ 23.1308, 25.1317, 27.1317, and 29.1317, High Intensity Radiated Fields (HIRF) Protection; §§ 23.1329, 25.1329, 27.1329, and 29.1329, Automatic Pilot System; §§ 23.1431, 25.1431, and 29.1431, Electronic Equipment; and §§ 23.1529, 25.1529, 27.1529, and 29.1529, Instructions for Continued Airworthiness.

b. Joint Aviation Requirements (JAR) 23, 25, 27, and 29. Copies of these documents may be purchased from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80152-5776; domestic calls: 1-800-854-7179; international calls: 1-303-397-7956; facsimile: 1-303-397-2740; electronic mail: global@ihs.com.; and web site: http://www.global.ihs.com.

c. AC 23.1309-1C, Equipment, Systems, and Installations in Part 23 Airplanes; and AC 25.1309-1A, System Design and Analysis. Copies of these documents may be purchased from the Superintendent of Documents, P.O. Box 371954, Pittsburgh, Pennsylvania 15250-7954; telephone: 1-202-512-1800; facsimile: 1-202-512-2250; web site: http://bookstore.gpo.gov.

d. RTCA/DO-160, Environmental Conditions and Test Procedures for Airborne Equipment, Revision D or later. Copies of this document may be purchased from RTCA, Inc., 1140 Connecticut Avenue SW., Suite 1020, Washington, DC 20036. This document is technically equivalent to EUROCAE ED-14. Anywhere there is a reference to RTCA/DO-160, EUROCAE ED-14 may be used.

e. European Organization for Civil Aviation Equipment (EUROCAE) Copies of these documents may be purchased from EUROCAE, 17 Rue Hamelin, F-75783, Paris, Cedex 16, France.

(1) EUROCAE ED-XX, "Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment." ED-XX and SAE ARP 5583, referenced below, are technically equivalent and either document may serve as the "Users Guide" referred to in this AC.

(2) EUROCAE ED-14 revision D or later. This document is technically equivalent to RTCA/DO-160. Anywhere there is a reference to RTCA/DO-160, EUROCAE ED-14 may be used.

f. Society of Automotive Engineers (SAE). Copies of the following documents may be obtained from SAE, 400 Commonwealth Drive, Warrendale, Pennsylvania 15096-0001; web site: http://www.sae.org.

(1) SAE ARP 5583 "Guide to Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment," Draft.

(2) SAE ARP 4754, "Certification Considerations for Highly-Integrated or Complex Aircraft Systems," November 1996.

(3) SAE ARP 4761, "Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment," December 1996.

4. BACKGROUND.

a. Aircraft Protection. Concern for the protection of aircraft electrical and electronic systems has increased substantially in recent years because of—

(1) Greater dependence on electrical and electronic systems performing functions required for continued safe flight and landing of an aircraft;

(2) Reduced electromagnetic shielding afforded by some composite materials used in aircraft designs;

(3) Increased susceptibility of electrical and electronic systems to HIRF because of increased data bus and processor operating speeds, higher density integrated circuits and cards, and greater sensitivities of electronic equipment;

(4) Expanded frequency usage, especially above 1 gigahertz (GHz);

(5) Increased severity of the HIRF environment because of an increase in the number and power of radio frequency (RF) transmitters; and

(6) Adverse effects experienced by some aircraft when exposed to HIRF.

b. HIRF Environment. The electromagnetic HIRF environment exists because of the transmission of electromagnetic radio frequency (RF) energy from radar, radio, television, and other ground-based, shipborne, or airborne RF transmitters. The User's Guide provides a detailed description of the derivation of these HIRF environments.

5. DEFINITIONS. For the purposes of this AC, the following definitions apply:

a. Attenuation. A term used to denote a decrease in electromagnetic field strength in transmission from one point to another. Attenuation may be expressed as a scalar ratio of the input magnitude to the output magnitude or in decibels (dB).

b. Bulk Current Injection (BCI). A method of electromagnetic interference (EMI) testing that involves injecting current into wire bundles through a current injection probe.

c. Continued Safe Flight and Landing. The capability for continued controlled flight and landing at a suitable location, possibly using emergency procedures, but without requiring exceptional pilot skill or strength. Some aircraft damage may be associated with a failure condition during flight or upon landing.

d. Continuous Wave (CW). An RF signal consisting of only the fundamental frequency with no modulation in amplitude, frequency, or phase.

e. Coupling. A process whereby electromagnetic energy is induced in a system by radiation produced by an RF source.

f. Current Injection Probe. An inductive device designed to inject RF signals directly into wire bundles when clamped around them.

g. Direct Drive Test. An EMI test that involves electrically connecting a signal source directly to the unit being tested.

h. Equipment. A component of an electrical or electronic system with interconnecting electrical conductors.

i. Equipment Electrical Interface. The location on a piece of equipment where an electrical connection is made to the other equipment in a system of which it is a part. The electrical interface may consist of individual wires or wire bundles that connect the equipment.

j. External High Intensity Radiated Fields Environment. The electromagnetic RF fields at the exterior of an aircraft.

k. Field Strength. The magnitude of the electromagnetic energy propagating in free space expressed in volts per meter (V/m).

l. High Intensity Radiated Fields (HIRF). The electromagnetic environment that exists from the transmission of high power RF energy into free space.

m. HIRF Vulnerability. The susceptibility characteristics of a system that cause it to suffer adverse effects when performing its intended function as a result of having been subjected to a HIRF environment.

n. Immunity. The capacity of a system or piece of equipment to continue to perform its intended function, in an acceptable manner, in the presence of RF fields.

o. Interface Circuit. The electrical or electronic device connecting the electrical inputs and outputs of equipment to other equipment or devices in an aircraft.

p. Internal HIRF Environment. The RF environment inside an airframe, equipment enclosure, or cavity. The internal RF environment is described in terms of the internal RF field strength or wire bundle current.

q. Margin. The difference between equipment susceptibility or qualification levels and the aircraft internal HIRF environment. Margin requirements may be specified to account for uncertainties in design, analysis, or test.

r. Modulation. A process whereby certain characteristics of a wave, often called the carrier wave, are varied in accordance with an applied function.

s. Radio Frequency (RF). A frequency useful for radio transmission. The present practical limits of RF transmissions are roughly 10 kilohertz (kHz) to 100 gigahertz (GHz). Within this frequency range, electromagnetic energy may be detected and amplified as an electric current at the wave frequency.

t. Reflection Plane. Conducting plate that reflects RF signals.

u. Similarity. The process of using existing HIRF compliance documentation and data from a system or aircraft to demonstrate HIRF compliance for a nearly identical system or aircraft of equivalent design, construction, and installation.

v. Susceptibility. The property of a piece of equipment that describes its capability to function acceptably when subjected to unwanted electromagnetic energy.

w. Susceptibility Level. The level where the effects of interference from electromagnetic energy become apparent.

x. System. A piece of equipment connected via electrical conductors to another piece of equipment, both of which are required to make a system function. A system may contain many pieces of equipment and wire bundles.

y. Transfer Function. The ratio of the electrical output of a system to the electrical input of a system, expressed in the frequency domain. For HIRF, a typical transfer function is the ratio of the current on a wire bundle to the external HIRF field strength, as a function of frequency.

z. Upset. An impairment of system operation, either permanent or momentary. For example, a change of digital or analog state that may or may not require a manual reset.

6. APPROACHES TO COMPLIANCE.

a. General. The following activities should be elements of a HIRF certification program. The iterative application of these activities is left to the applicant and adherence to the sequence shown is not necessary. The applicant should—

(1) Identify the systems to be assessed;

(2) Establish the applicable external HIRF environment;

(3) Establish the test environment for installed systems;

(4) Apply the appropriate method of HIRF compliance verification; and

(5) Verify compliance with HIRF certification requirements.

b. Identify the Systems to be Assessed.

(1) General. The aircraft systems that require HIRF assessment must be identified. The process used for identifying these systems should be similar to the process for showing compliance with §§ 23.1309, 25.1309, 27.1309, and 29.1309, as applicable. These sections address any system failure that may cause or contribute to an effect on the safety of flight of an aircraft. The effects of an encounter with HIRF, therefore, should be assessed in a manner that allows for the determination of the degree to which the aircraft and/or its systems safety may be influenced. The operation of the aircraft systems should be

assessed separately and in combination with, or in relation to, other systems. This assessment should cover all normal aircraft operating modes, stages of flight, and operating conditions; all failure conditions and their subsequent effect on aircraft operations and the flightcrew; and any corrective actions required.

(2) Safety Assessment. A safety assessment related to HIRF should be performed to establish and classify the equipment or system failure condition. Table 1 provides the corresponding failure condition classification and system HIRF certification level for the appropriate HIRF regulations. The failure condition classifications and terms used in this AC are similar to those used in AC 23.1309-1C and AC 25.1309-1A, as applicable. Only those systems identified as performing or contributing to functions whose failure would result in catastrophic, hazardous, or major failure conditions are subject to HIRF regulations. The failure classifications "minor" and "no safety effect" used in AC 23.1309-1C and AC 25.1309-1A are not used in this AC. Based on the failure condition classification established by the safety assessment, the systems should be assigned appropriate HIRF certification levels, as shown in table 1. Further guidance on performing the safety assessment can be found in AC 23.1309-1C, AC 25.1309-1A, SAE ARP 4754, and SAE ARP 4761.

Table 1 – HIRF Failure Conditions and System HIRF Certification Levels

HIRF Requirements Excerpts from §§ 23.1308, 25.1317, 27.1317, and 29.1317	Failure Condition	System HIRF Certification Level
Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the rotorcraft/airplane	Catastrophic	A
Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the rotorcraft/airplane or the ability of the flightcrew to cope with adverse operating conditions	Hazardous	B
Each electrical and electronic system that performs such a function whose failure would reduce the capability of the	Major	C

rotorcraft/airplane or the ability of the flightcrew to cope with adverse operating conditions		

(3) Failure Conditions. The safety assessment may show that some systems have different failure conditions in different phases of flight; therefore, different HIRF requirements may have to be applied to the system for different phases of flight. For example, an automatic flight control system may have a catastrophic failure condition for autoland, while automatic flight control system operations in cruise may have a hazardous failure condition.

c. Establish the Applicable Aircraft External HIRF Environment. The external HIRF environments I, II, and III used for aircraft HIRF certification are shown in tables 2, 3, and 4, respectively. The field strength values for the HIRF environments and test levels are expressed in root-mean-square (rms) units measured during the peak of the modulation cycle, which is how many laboratory instruments indicate amplitude.

Table 2 — HIRF ENVIRONMENT I

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	50	50
100 kHz - 500 kHz	50	50
500 kHz - 2 MHz	50	50
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	50	50
70 MHz - 100 MHz	50	50
100 MHz - 200 MHz	100	100
200 MHz - 400 MHz	100	100
400 MHz - 700 MHz	700	50
700 MHz - 1 GHz	700	100
1 GHz - 2 GHz	2,000	200
2 GHz - 4 GHz	3,000	200
4 GHz - 6 GHz	3,000	200
6 GHz - 8 GHz	1,000	200
8 GHz - 12 GHz	3,000	300
12 GHz - 18 GHz	2,000	200
18 GHz - 40 GHz	600	200

In this table, the higher field strength applies at the frequency band edges.

Table 3 — HIRF ENVIRONMENT II

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	20	20
100 kHz - 500 kHz	20	20
500 kHz - 2 MHz	30	30
2 MHz - 30 MHz	100	100
30 MHz - 70 MHz	10	10
70 MHz - 100 MHz	10	10
100 MHz - 200 MHz	30	10
200 MHz - 400 MHz	10	10
400 MHz - 700 MHz	700	40
700 MHz - 1 GHz	700	40
1 GHz - 2 GHz	1,300	160
2 GHz - 4 GHz	3,000	120
4 GHz - 6 GHz	3,000	160
6 GHz - 8 GHz	400	170
8 GHz - 12 GHz	1,230	230
12 GHz - 18 GHz	730	190
18 GHz - 40 GHz	600	150
In this table, the higher field strength applies at the frequency band edges.		

Table 4 — HIRF ENVIRONMENT III

FREQUENCY	FIELD STRENGTH (V/M)	
	PEAK	AVERAGE
10 kHz - 100 kHz	150	150
100 kHz - 500 kHz	200	200
500 kHz - 2 MHz	200	200
2 MHz - 30 MHz	200	200
30 MHz - 70 MHz	200	200
70 MHz - 100 MHz	200	200
100 MHz - 200 MHz	200	200
200 MHz - 400 MHz	200	200
400 MHz - 700 MHz	730	200
700 MHz - 1 GHz	1,400	240
1 GHz - 2 GHz	5,000	250
2 GHz - 4 GHz	6,000	490
4 GHz - 6 GHz	7,200	400
6 GHz - 8 GHz	1,100	170
8 GHz - 12 GHz	5,000	330
12 GHz - 18 GHz	2,000	330
18 GHz - 40 GHz	1,000	420
In this table, the higher field strength applies at the frequency band edges.		

d. Establish the Test Environment for Each System.

(1) General. The external HIRF environment will penetrate the aircraft and establish an internal RF environment to which installed electrical and electronic systems will be exposed. The resultant internal RF environment is caused by a combination of factors, such as aircraft seams and apertures, reradiation from the internal aircraft structure and wiring, and characteristic aircraft electrical resonance.

(2) Level A Systems. The resulting internal HIRF environments for level A systems are determined by aircraft attenuation to HIRF environments I, II, or III, as applicable. The attenuation is aircraft- and zone-specific and should be established by aircraft test, analysis, or similarity. Further details are in paragraph 10 of this AC.

(3) Level B Systems. The internal RF environments for level B systems are defined in appendix J to Part 23, appendix K to Part 25, appendix D to Part 27, and appendix E to Part 29, as applicable, as equipment HIRF test levels 1, 2, and 3. Further details are in paragraph 10 of this AC.

(4) Level C Systems. The internal RF environment for level C systems is defined in appendix J to Part 23, appendix K to Part 25, appendix D to Part 27, and appendix E to Part 29, as applicable, as equipment HIRF test level 4. Further details are in paragraph 10 of this AC.

e. Apply the Appropriate Test Requirements. Table 5 summarizes the relationship between the aircraft performance requirements in the HIRF regulations, and the HIRF environments and test levels.

Table 5 - HIRF Certification Requirements Summary

HIRF Failure Condition from §§ 23.1308, 25.1317, 27.1317, and 29.1317	Performance Criteria	Item the Environment or Test Level Applies To	HIRF Environment or Test Level
Each electrical and electronic system that performs a function whose failure would prevent the continued safe flight and landing of the airplane/rotorcraft must be designed and installed so that–	Each function is not adversely affected during and after the time	the airplane/rotorcraft	is exposed to HIRF environment I.
	Each electrical and electronic system automatically recovers normal operation, in a timely manner after … unless this conflicts with other operational or functional requirements of that system	the airplane/rotorcraft	is exposed to HIRF environment I.
	Each electrical and electronic system is not adversely affected during and after	the airplane/rotorcraft	is exposed to HIRF environment II.
	Each function required during operation under visual flight rules is not adversely affected during and after	the rotorcraft	is exposed to HIRF environment III (Parts 27 and 29 only).
Each electrical and electronic system that performs a function whose failure would significantly reduce the capability of the airplane/rotorcraft or the ability of the flightcrew to cope with adverse operating conditions must be designed and installed so that–	the system is not adversely affected when	the equipment providing these functions	is exposed to equipment HIRF test level 1, 2, or 3.
Each electrical and electronic system that performs such a function whose failure would reduce the capability of the	the system is not adversely affected when	the equipment providing these functions	is exposed to equipment HIRF test level 4.

airplane/rotorcraft or the ability of the flightcrew to cope with adverse operating conditions must be designed and installed so that—			

f. Verification of Compliance with the Certification Requirements.

(1) General. Verification of compliance with the HIRF certification requirements should be shown by evidence that the internal HIRF environment at equipment interfaces and enclosures does not exceed the equipment's or system's HIRF test levels.

(2) Pass/Fail Criteria. The specific HIRF compliance pass/fail criteria for each system, related to the applicable HIRF regulation performance criteria, should be established by the applicant and approved by the FAA. The means for monitoring system performance relative to these criteria also should be established by the applicant and approved by the FAA. All effects that define the pass/fail criteria should be the result of identifiable and traceable analysis that includes both the separate and interdependent operational characteristics of the systems. The analysis should evaluate the failures, either singularly or in combination, that could adversely affect system performance. This should include failures that could negate any built-in redundancy within the system or could influence more than one system performing the same function.

7. MARGINS. A margin may be necessary to account for uncertainties involved in analyses and test measurements. A margin normally is not required for analyses or measurements that are based on proven data. Where data have limited background for substantiation, a margin may be required depending on the available justifications. The User's Guide contains a detailed description of margins.

8. AIRCRAFT TYPE CERTIFICATIONS. The design and verification data to support a submission for a TC, amended TC, or STC should be acquired through a logical and traceable procedure. The procedure should begin with the definition stage, where the system requirements are generated and defined, and end with demonstration of compliance with system requirements. HIRF compliance considerations should be included as a part of the certification plan.

9. HIRF COMPLIANCE.

a. HIRF Compliance Plan. An overall HIRF compliance plan should be established to clearly identify and define HIRF certification requirements, HIRF protection development, and the design, test, and analysis activities intended to be part of the compliance effort. This plan should provide definitions of the aircraft systems, installations, and protective features against which HIRF compliance will be assessed. The HIRF compliance plan should be discussed with and submitted to the FAA for approval before being implemented. If the aircraft, system, or installation design changes after FAA approval, a revised HIRF compliance plan should be submitted to the FAA for approval. The HIRF compliance plan should include the following:

(1) A HIRF compliance plan summary;

(2) Identification of the aircraft systems, with classification based on the safety assessment as it relates to HIRF;

(3) The HIRF environment for the aircraft and installed systems; and

(4) The verification methods, such as test, analysis, or similarity.

b. HIRF Verification Test, Analysis, or Similarity Plan. Specific HIRF test, analysis, or similarity plans should be prepared to describe specific verification activities. One or more verification plans may be necessary. For example, there may be several systems or equipment laboratory test plans, an aircraft test plan, or a similarity plan for selected systems on an aircraft.

(1) Test Plan.

(a) A HIRF compliance test plan should include the objectives, both at equipment and system level, for the acquisition of data to support HIRF compliance verification. The plan should provide an overview of the factors being addressed for each system test requirement and should not list only the test items and intended test locations. The test plan should include the following information:

1. The purpose of the test,

2. A description of the aircraft and/or system being tested,

3. System configuration drawings,

4. The proposed test setup and methods,

5. Intended test levels and frequency bands,

6. Pass/fail criteria, and

7. The test schedule and test location.

(b) The test plan should cover the level A, B, or C systems and equipment. Level A systems may require both a laboratory and an installed-on-aircraft test. Level A display systems may require an integrated system rig test, in addition to a generic attenuation assessment. Level B or level C systems and equipment may require only equipment bench testing.

(c) The test plan should describe the appropriate aspects of the systems to be tested and their installation. Additionally, the test plan should reflect the results of any analysis performed in the overall process of the HIRF compliance evaluation.

(2) Analysis Plan. A HIRF compliance analysis plan should include the objectives, both at the system and equipment level, for generating data to support HIRF compliance verification. Comprehensive modeling and analysis for RF field coupling to aircraft systems and structures is an emerging technology; therefore, the analysis plan should be coordinated with the FAA to determine an acceptable scope for the analysis. The analysis plan should include—

(a) The purpose and scope of the analysis;

(b) A description of the aircraft and/or system addressed by the analysis;

(c) System configuration descriptions;

(d) Proposed analysis methods;

(e) The approach for validating the analysis results; and

(f) Pass/fail criteria, including margins to account for analysis uncertainty.

(3) Similarity Plan. A similarity plan should describe the approach undertaken to use the certification data from previously certified systems, equipment, and aircraft in the proposed HIRF compliance program. The similarity plan should include—

(a) The purpose and scope of the similarity assessment;

(b) Specific systems addressed by the similarity assessment;

(c) Data that will be used from the previously certified systems, equipment, and aircraft; and

(d) Any significant differences between the aircraft and system installation proposed for certification and the aircraft and system installation from which the data will be used.

c. Compliance Reports. One or more compliance reports may be necessary to document the results of test, analysis, or similarity assessments. For new or significantly modified aircraft, HIRF compliance reports may include many system and equipment test reports, aircraft test reports, and HIRF vulnerability analysis reports. For these types of HIRF certification programs, a compliance summary report may be useful to summarize the results of tests and analysis. For HIRF certification programs on relatively simple systems, a single compliance report may be adequate.

(1) Test Reports. Comprehensive test reports should be produced at the conclusion of HIRF compliance testing. The test reports should include descriptions of the salient aspects of equipment or system performance during the test, details of any area of noncompliance with HIRF requirements, actions taken to correct the noncompliance, and any similarity declarations. Any supporting rationale related to any observed deviations from system performance during testing also should be provided.

(2) Analysis Reports. Analysis reports should describe the details of the analytical model, the methods used to perform the analysis, and the results of the analysis. The reports should identify any modeling uncertainty.

(3) Similarity Reports. The similarity reports should document the significant aircraft, system, equipment, and installation features common between the aircraft or system that is the subject of the similarity analysis and the aircraft or system that previously was certified for HIRF. Any significant differences should be identified, along with the assessment of the impact of these differences on HIRF compliance.

d. Major Elements of Compliance Verification.

(1) Various methods are available to aid in demonstrating HIRF compliance. These methods are described in the following paragraphs and represent those that have evidence of practical application and are acceptable to the FAA. Figures 1 and 2 outline the possible steps to HIRF compliance for systems requiring level A, B, or C HIRF certification.

(2) Other HIRF compliance techniques may be considered to demonstrate system performance in the HIRF environment, but should be approved by the FAA before their use.

Figure 1 – Routes to HIRF Compliance

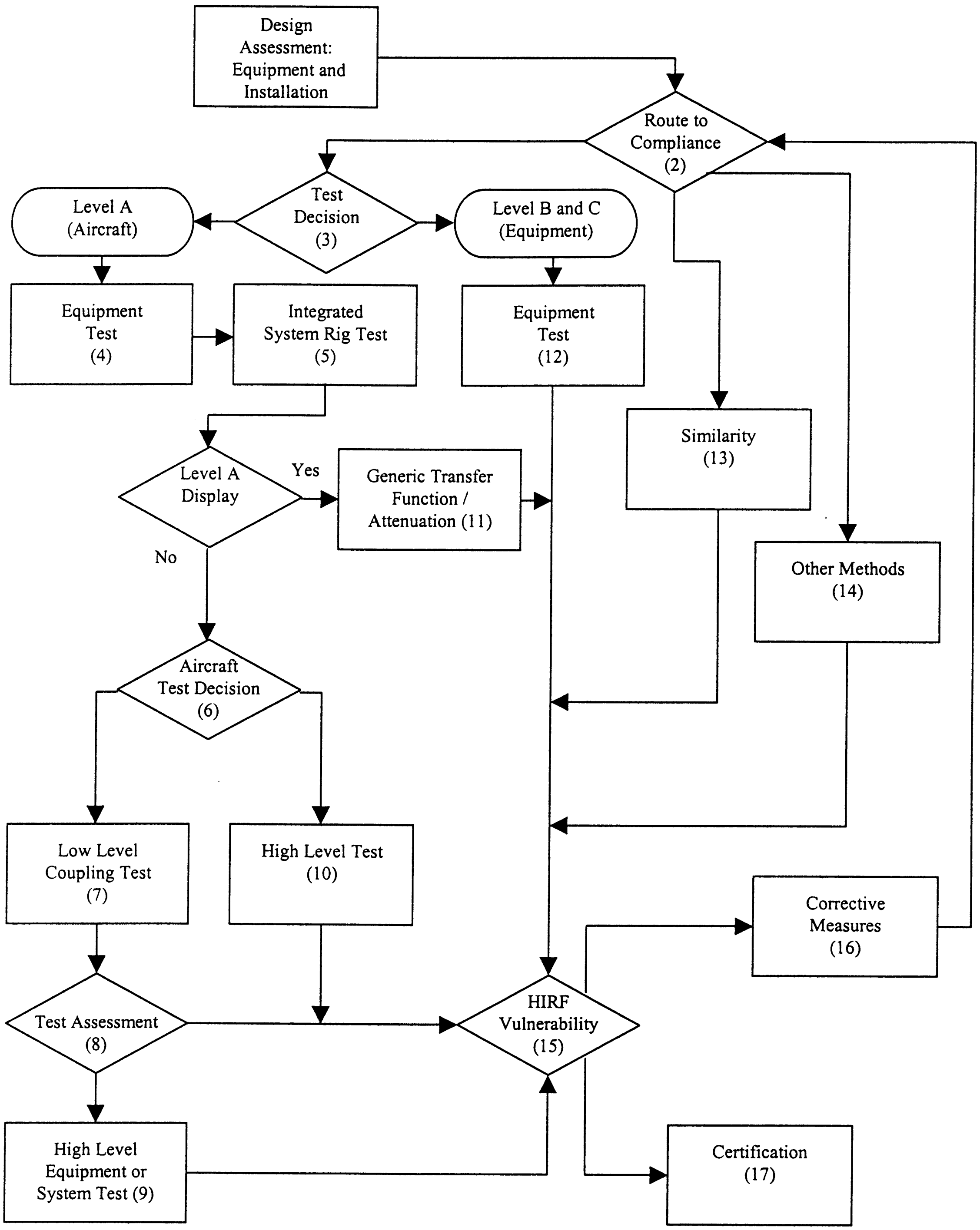
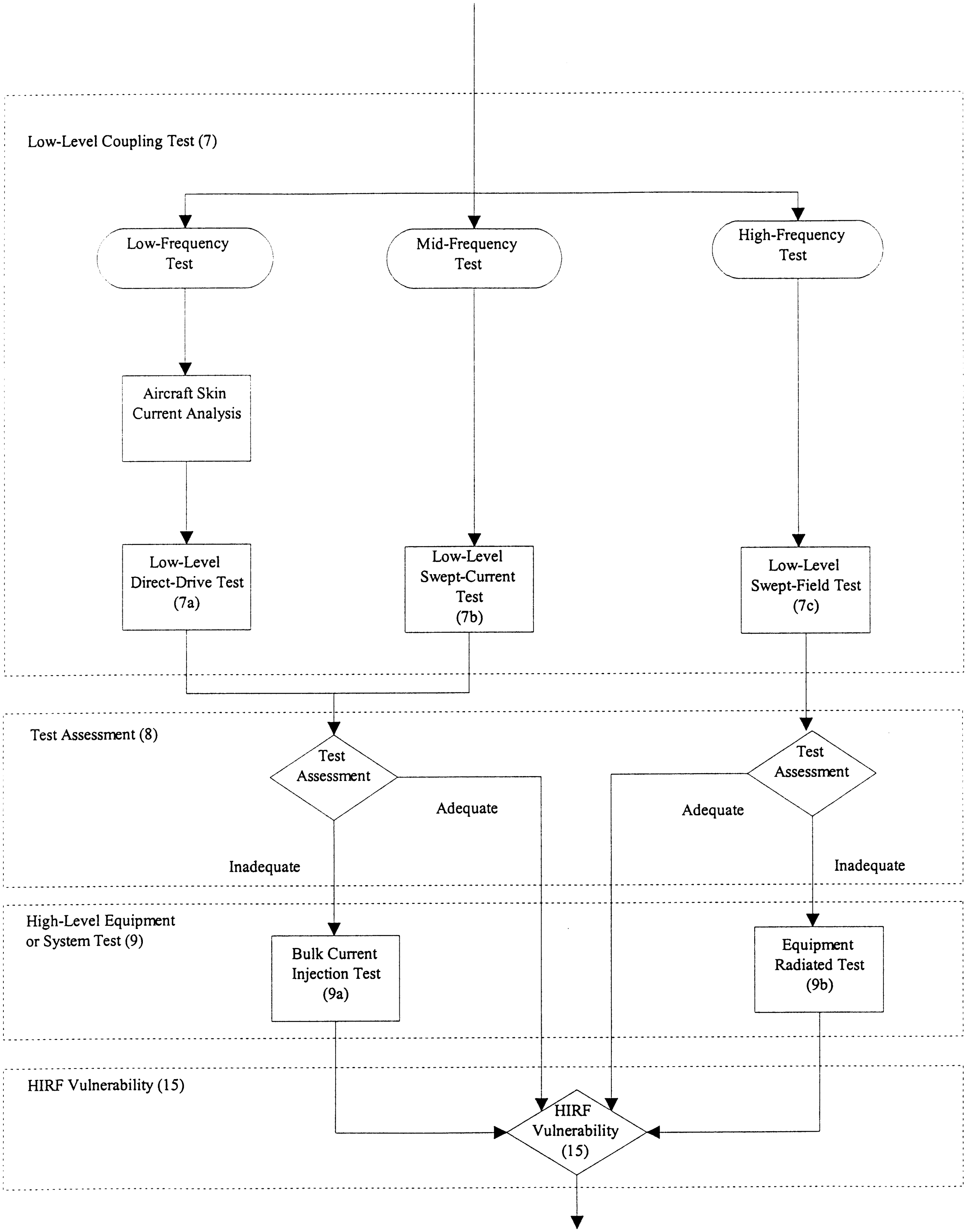


Figure 2 – Routes to HIRF Compliance (Steps 7 through 9)



10. STEPS TO HIRF COMPLIANCE.

a. Step 1 – Design Assessment: Equipment and Installation.

(1) The initial step in HIRF compliance is to determine the HIRF environment to which the aircraft, equipment, or system should be exposed. The equipment or system failure condition classification should be determined from a safety assessment. According to the system failure condition classification, the system will be designated as level A, B, or C. The HIRF environment to which the aircraft, equipment, or system will be exposed is based on whether the system is designated as level A, B, or C.

(2) Because equipment or system tests may occur before aircraft-level testing and before the actual internal HIRF environment is known, the equipment or system test levels should be selected based on an estimate of the expected internal HIRF environment.

b. Step 2 – Route to Compliance. The route to be taken for HIRF compliance will vary depending on whether the system was designated as level A, B, or C. The decision should be made whether to use test (step 3), similarity (step 13), or other methods (step 14), including analysis for HIRF compliance verification.

c. Step 3 – Test Decision. Level A systems will require an aircraft assessment and should proceed to step 4. Level B and C systems will require equipment testing and should proceed to step 12.

d. Step 4 – Equipment Test.

(1) The radiated and conducted RF susceptibility test procedures of RTCA/DO-160, revision D or later, section 20, or equivalent, may be used to build confidence in the equipment's performance before conducting integrated system rig testing in step 5. The equipment should be tested in accordance with the test levels (wire bundle currents and RF field strengths) of RTCA/DO-160, revision D or later, or to a level derived from the analysis of the aircraft and equipment installation for a given external HIRF environment.

(2) Equipment development testing may be used to augment the compliance test submission where appropriate. If equipment that was not subject to the equipment qualification testing of paragraph 10.d.(1) above is used within the system to be tested, then the HIRF compliance certification may be achieved by step 5, and step 4 may be omitted.

e. Step 5 – Integrated System Rig Test.

(1) A radiated and conducted RF susceptibility test on an integrated system rig should be performed for level A systems.

(2) If the results of the tests conducted on an integrated system rig are comparable to the results obtained in step 7 and characterize the equipment's or system's final installation in the aircraft, high-level tests on equipment or systems in step 9 may not be required.

(3) The physical installation of the equipment or system in the integrated system rig assembly should be similar to that used in the aircraft. For example, the bonding and grounding of the system, the wiring harness detail, and the relative position of the elements to each other and the ground plane should match closely the equipment's or system's installation on the aircraft to be certificated.

(4) The internal HIRF environment should be determined by using analysis, previous coupling/attenuation data from similar aircraft types, or, for level A display systems only, the generic transfer function/attenuation curves in appendix 1 to this AC.

(5) A method of comparing the integrated system rig test of step 5 with the internal RF current or RF fields measured during the low-level coupling test of step 7 should be defined to show that the internal RF environment is lower than the equipment or system test levels in step 15, HIRF vulnerability. This method should be included in the HIRF compliance plan. The method should enable a direct comparison between the equipment or system test level and the aircraft internal HIRF environment at the equipment or system location, in terms of field strength (>100 megahertz (MHz)) and current (<400 MHz). The comparison method should ensure that—

(a) The laboratory test configuration includes all significant aspects of the aircraft installation considered necessary in the demonstration process for that portion of the system to be certified.

(b) The system is tested in an operational state with the input sensors operational. The input sensors may be simulated by test sets, provided the test sets accurately represent the terminating impedance of the sensor. Additionally, the sensors should be evaluated individually and shown to meet the HIRF requirements with respect to their locations.

(c) The test procedures used and test levels employed are selected to simulate the conditions created by the aircraft internal HIRF environment when the aircraft operates in the appropriate external HIRF environment. Suitable test procedures are described in detail in the User's Guide. BCI tests should be used from 10 kHz to 400 MHz, and radiated susceptibility testing should be used from 100 MHz to 18 GHz.

(6) The test time may be minimized by using only the modulation to which the system under evaluation is most sensitive. The User's Guide provides guidance on modulation selection and suggested default modulations and dwell times.

(7) Standard RTCA/DO-160, revision D or later, equipment tests normally are not sufficient to show HIRF compliance for step 5. However, if the requirements of paragraphs 10.e.(5)(a), (b), and (c) above are met, then the standard integrated system rig tests can be used.

f. Step 6 – Aircraft Test Decision.

(1) Various aircraft test procedures are available, recognized, and accepted for collecting data for HIRF compliance verification. The two main approaches to aircraft testing are the low-level coupling test (step 7) and the high-level test (step 10). Low-level coupling involves measuring the airframe attenuation and confirming that the integrated system rig test levels reflect the internal HIRF environment measured. The high-level equipment field-illumination test involves radiating the aircraft at test levels equal to the applicable external HIRF environment as provided in paragraph 6.c. of this AC.

(2) Some test procedures may be more appropriate than others because of the size of the aircraft and the practicality of illuminating the entire aircraft with the appropriate external HIRF environment. The HIRF compliance testing proposed in figure 2 may be more suitable for testing large aircraft than the high-level equipment field-illumination test in step 10, which requires illumination of the entire aircraft with the external HIRF environment.

g. Step 7 – Low-Level Coupling Test.

(1) General.

(a) The low-level coupling test involves three different tests, briefly described below, that cover the frequency range of 10 kHz to 18 GHz (see figure 2). Detailed descriptions are available in the User's Guide. Other techniques may be valid and should be discussed with and approved by the FAA before being used.

(b) The low-level direct-drive test (step 7a) and the low-level swept-current test (step 7b) are used for frequencies below 400 MHz, and the low-level swept-field test (step 7c) is used for frequencies above 400 MHz. There is an overlap of test frequencies from 100 MHz to 400 MHz in the low-level swept-current test and the low-level swept-field test. The division at 400 MHz is not absolute but rather depends on when HIRF penetration of the equipment case becomes a significant factor.

(c) Low-level coupling tests should cover the frequency range of 10 kHz to 18 GHz.

(2) Step 7a – Low-Level Direct-Drive Test. Low-level direct-drive tests should be used to measure the transfer function between the skin current and individual equipment wire bundle currents. This test is typically used in the frequency range from 10 kHz to the first airframe resonance. For the low-level direct-drive test to be applied successfully, a three-dimensional model of the aircraft should be derived using aircraft skin current analysis (see the User's Guide) such that the three-dimensional model can then be used to derive a representation of the aircraft's skin current pattern for a given external HIRF environment. If the relationship between the external HIRF environment and the skin current is known for all illumination angles and polarization, either because of aircraft skin current analysis or the use of the low-level swept-current test, the skin current can be

set up by direct injection into the airframe. The resultant currents on the aircraft or equipment wire bundles are measured with a current probe and normalized to the external unit field strength so they can be scaled to the appropriate external HIRF environment. This test method has improved sensitivity over the low-level swept-current test and may be necessary for small aircraft or aircraft with high levels of fuselage shielding.

(3) Step 7b – Low-Level Swept-Current Test.

(a) The low-level swept-current test involves illuminating the aircraft with an external HIRF field to measure the transfer function between the external field and the aircraft and equipment wire bundle currents. This test is typically used in the frequency range of 0.5 MHz to 400 MHz. The transfer function is resonant in nature and is dependent on both the aircraft structure and the equipment or system installation. Because the transfer function relates wire bundle currents to the external field, the induced bulk current injection test levels can be related to an external HIRF environment.

(b) Transmit antennas should be placed at four separate positions around the aircraft, typically the nose, tail, and each wing. The aircraft should be illuminated by one antenna at a time with both horizontally and vertically polarized swept frequency fields, and the currents induced on the aircraft wire bundles should be measured. The ratio between the induced wire bundle current and the illuminating antenna field strength should be calculated and normalized to 1 V/m. This calculation should provide the transfer function in terms of induced current per unit external field strength that can then be extrapolated to the required HIRF field strength by multiplying the induced current at 1 V/m by the external HIRF field strength. The extrapolated HIRF currents for all measurement configurations for each aircraft wire bundle being assessed should be overlaid and a worst-case induced current profile should be produced. These current profiles should be compared with the induced current measured during the tests in step 5 or step 9. When compared with the current measured during tests in step 5, the comparison may not show equivalence because of changes in equipment or system installation, for example, wire bundle lengths, screening and bonding, wire bundle composition, or differences between equipment qualification and aircraft test levels.

(c) The worst-case current signature for a particular wire bundle should be compared to the current induced at the particular test level or equipment malfunction over discrete frequency ranges such as 0.05 MHz to 0.5 MHz, 0.5 MHz to 30 MHz, and 30 MHz to 100 MHz. This comparison should be broken into discrete frequency ranges because the resonance may differ between equipment test and aircraft test levels.

(4) Step 7c – Low-Level Swept-Field Test. Low-level swept-field testing is typically used from 100 MHz to 18 GHz. The test procedures for the low-level swept-field test are similar to those used for the low-level swept-current test; however, in the low-level swept-field test, the internal RF fields in the vicinity of the equipment are measured instead of the wire bundle currents. Various techniques can be used to ensure the maximum internal field in the vicinity of the equipment is measured. Depending on the size of the aircraft and the size of the aircraft cabin, flight deck, and equipment bays, multipoint measurement or mode stirring can be used. See the User's Guide for detailed low-level swept-field test procedures.

h. Step 8 – Test Assessment.

(1) At this point, the internal RF fields and wire bundle currents produced by the appropriate external HIRF environment should be known based on the measurements made in step 7. These measurements should be compared with the test levels used in step 5.

(2) Step 9a should be performed on the aircraft or a representative system integration rig if the above comparison shows that–

(a) Significant configuration differences were identified between the integrated system rig used for conducted RF susceptibility testing in step 5, and the actual aircraft system installation;

(b) The conducted RF susceptibility test levels used in step 5 were too low when compared with the aircraft-induced currents measured in step 7; or

(c) Potential HIRF susceptibility may exist.

(3) Step 9b should be performed on systems installed on the aircraft or a representative integrated system rig if the above comparison shows that–

(a) Significant configuration differences were identified between the integrated system rig used for radiated RF susceptibility testing in step 5, and the actual aircraft system installation;

(b) The RF fields used in step 5 were too low when compared with the aircraft internal fields measured in step 7; or

(c) Potential HIRF susceptibility may exist.

(4) If the measurements made in step 5 are comparable to those made in step 7, then step 9 may be omitted and step 15 should be performed next.

i. Step 9 – High-Level Equipment or System Test.

(1) General. The various procedures that should be used in this step are described briefly below. Detailed descriptions are available in the User's Guide. Other techniques may be valid, but should be proposed in the HIRF compliance plan and approved by the FAA before use.

(2) Overlap Procedures. The high-level test procedures are typically divided at 400 MHz. The division at 400 MHz is not definitive but rather depends on when RF penetration of the equipment case becomes a factor. It is therefore necessary to overlap the two procedures described below to ensure the primary coupling route is tested.

(3) Step 9a – Bulk Current Injection Test.

(a) High-level wire bundle bulk current injection (BCI) should be used at frequencies below 400 MHz to measure the current at equipment malfunction or equipment test levels when RF currents are injected into the equipment wiring via a current transformer.

(b) The system should be tested using the test levels determined in step 7a or step 7b. Each wire bundle in the system should be injected and the induced wire bundle current measured. If a wire bundle branches, then each relevant wire branch containing system wiring should be tested.

(c) To ensure the systems under test are tested when operating at their maximum sensitivity, each system should be operational and the aircraft or integrated system rig should be placed in various simulated operating modes. Simultaneous multi-bundle BCI may be necessary on systems where, for example, there are redundant/multichannel architectures.

(d) The test time should be minimized by using only the modulation to which the system under evaluation is most sensitive. See the User's Guide for guidance on modulation selection and suggested default modulations and dwell times.

(4) Step 9b – Equipment Radiated Test.

(a) High-level equipment radiated susceptibility tests should be used at frequencies greater than 100 MHz. The equipment should be installed on the aircraft. The internal RF field in the vicinity of the equipment under evaluation should be determined using the transfer function or attenuation measured in step 7 and the appropriate external HIRF environment. The equipment under evaluation should be radiated by this HIRF environment using antennas inside the aircraft in the vicinity of the equipment. The radiating antenna should be far enough away to ensure the total volume of the equipment and that at least half a wavelength of the wiring is simultaneously and uniformly illuminated during the test.

(b) The test time should be minimized by using only the modulation to which the system under evaluation is most sensitive. See the User's Guide for guidance on modulation selection and suggested default modulations and dwell times.

j. Step 10 – High-Level Test.

(1) General.

(a) The high-level test requires the generation of RF fields external to an aircraft at a level equal to the applicable external HIRF environment.

(b) At frequencies below 400 MHz, the aircraft and the radiating antenna should be separated to ensure the aircraft is illuminated uniformly by the external HIRF environment. Typically, four radiating antenna positions should be used, illuminating the nose, tail, and each wingtip. The aircraft should be illuminated by one antenna at a time, with both horizontally and vertically polarized fields. The RF field should be calibrated by measuring the RF field strength in the center of the test volume before the aircraft is placed there.

(c) At frequencies above 400 MHz, the RF illumination should be localized to the system under test, provided all parts of the system and at least one wavelength of any associated wiring (or the total length if less than one wavelength) are illuminated uniformly by the RF field. Relevant apertures on the bottom and top of the aircraft should be illuminated by using reflection planes.

(d) To ensure the systems are tested when operating at their maximum sensitivity, level A systems should be fully operational and the aircraft should be placed in various simulated operating modes.

(e) The test time should be minimized by using only the modulation to which the system under evaluation is most sensitive. The User's Guide provides guidance on modulation selection and suggested default modulations and dwell times.

(2) Aircraft High-Level Direct-Drive Test. As an alternative to testing at frequencies below the first airframe resonance, it is possible to inject high-level currents directly into the airframe using the techniques similar to those described in step 7. Aircraft skin current analysis should be performed as described in the User's Guide, or low-level swept-current measurements should be made to determine the skin current distribution that will exist for different RF field polarizations and aircraft illumination angles so that these can be simulated accurately during this test. Aircraft high-level direct-drive testing, although applicable only from 10 kHz to the first aircraft resonant frequency, is advantageous because it is possible to test all systems simultaneously.

k. Step 11 – Generic Attenuation (Level A Display Systems).

(1) Level A displays involve functions for which the pilot will be within the loop through pilot/system information exchange. For level A display systems, the aircraft attenuation data may be determined by analysis using generic attenuation and transfer function data. This approach should not be used for other level A systems, such as control systems, because failures and malfunctions of

those systems can more directly and abruptly contribute to a catastrophic failure event than display system failures and

malfunctions; therefore, other level A systems require a more rigorous HIRF compliance verification program.

(2) The test levels required in Step 5 may be derived from the generic transfer function and attenuation curves for the different types of aircraft. Acceptable transfer function curves for calculating the test levels are given in appendix 1 to this AC. Appendix 1 to this AC also contains guidelines for selecting the proper generic attenuation curve. These curves show the envelope of the peak currents that might be expected to be induced in the generic types of aircraft in an external HIRF environment of 1 V/m. The peak current levels should be multiplied linearly by the appropriate external HIRF environment to provide the test levels within the limits described in the User's Guide.

(3) The internal HIRF environment would be, in V/m, the external HIRF environment divided by the appropriate attenuation, in linear units. For example, 20 dB or a 10:1 attenuation means the test level is the relevant external HIRF environment reduced by a factor of 10 in terms of electric field strength.

(4) The internal HIRF environments also can be measured using on-aircraft low-level coupling measurements of the actual equipment installation. This procedure should provide more accurate information to the user, and the test levels may be lower than the generic curves, as the generic curves are worst-case estimates.

l. <u>Step 12 – Equipment Test (for Level B and Level C Systems)</u>.

(1) <u>General</u>. Level B or level C systems do not require the same degree of HIRF compliance testing as level A systems. Level B or level C systems do not require aircraft-level testing; standard RTCA/DO-160, revision D or later, test procedures, using suitably defined equipment or system test levels, should be used. The test limits used should depend on whether the system is categorized as level B or level C. When applying modulated signals, the test levels are given in terms of the peak of the test signal as measured by a rms-indicating spectrum analyzer's peak detector. See the User's Guide for more details on modulation.

(2) Level B Systems. Equipment HIRF test level 1, 2, or 3 from the HIRF regulation must be used for level B systems. Test Category R in RTCA/DO-160 revision D, section 20, is the same as equipment HIRF test levels 1 and 2. Equipment HIRF test levels 1, 2, and 3 from appendix J to Part 23, appendix K to Part 25, appendix D to Part 27, and appendix E to Part 29, as applicable, are repeated here for convenience.

(a) Equipment HIRF Test Level 1.

1. From 10 kHz to 400 MHz, use conducted susceptibility tests with continuous wave (CW) and 1 kHz square wave modulation with 90 percent depth or greater. The conducted susceptibility current must start at a minimum of 0.6 milliamperes (mA) at 10 kHz, increasing 20 dB per frequency decade to a minimum of 30 mA at 500 kHz.

2. From 500 kHz to 400 MHz, the conducted susceptibility current must be at least 30 mA.

3. From 100 MHz to 400 MHz, use radiated susceptibility tests at a minimum of 20 volts per meter (V/m) peak, with CW and 1 kHz square wave modulation with 90 percent depth or greater.

4. From 400 MHz to 8 gigahertz (GHz), use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 0.1 percent duty cycle with 1 kHz pulse repetition frequency. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 percent.

5. From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 28 V/m peak with 1 kHz square wave modulation with 90 percent depth or greater. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 percent.

(b) Equipment HIRF Test Level 2.

1. From 10 kHz to 400 MHz, use conducted susceptibility tests with CW and 1 kHz square wave modulation with 90 percent depth or greater. The conducted susceptibility current must start at a minimum of 0.6 mA at 10 kHz, increasing 20 dB per frequency decade to a minimum of 30 mA at 500 kHz.

2. From 500 kHz to 400 MHz, the conducted susceptibility current must be at least 30 mA.

3. From 100 MHz to 400 MHz, use radiated susceptibility tests at a minimum of 20 V/m peak with CW and 1 kHz square wave modulation with 90 percent depth or greater.

4. From 400 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 150 V/m peak with pulse modulation of 4 percent duty cycle with a 1 kHz pulse repetition frequency. This signal must be switched on and off at a rate of 1 Hz with a duty cycle of 50 percent.

(c) Equipment HIRF Test Level 3. Test level 3 is HIRF environment II reduced by acceptable aircraft transfer function and attenuation curves. Testing must cover the frequency band of 10 kHz to 8 GHz. Generic aircraft transfer function and attenuation curves shown in appendix 1 to this AC are acceptable for determining equipment HIRF test level 3.

(3) Level C Systems. Equipment HIRF test level 4 should be used to test level C systems. Category T in RTCA/DO-160, revision D, section 20, is the same as equipment HIRF test level 4. Equipment HIRF test level 4 from appendix J to Part 23, appendix K to Part 25, appendix D to Part 27, and appendix E to Part 29, as applicable, is repeated here for convenience.

(a) From 10 kHz to 400 MHz, use conducted susceptibility tests, starting at a minimum of 0.15 mA at 10 kHz, increasing 20 dB per frequency decade to a minimum of 7.5 mA at 500 kHz.

(b) From 500 kHz to 400 MHz, use conducted susceptibility tests at a minimum of 7.5 mA.

(c) From 100 MHz to 8 GHz, use radiated susceptibility tests at a minimum of 5 V/m.

m. Step 13 – Similarity.

(1) General. The rules for applying similarity as a means of compliance vary according to the equipment/system failure condition classification.

(2) Level A Systems.

(a) Systems previously certified on one aircraft model may be certified by similarity in another aircraft model as described below. Similarity is not applicable for level A systems consisting of new equipment designs installed in an aircraft with a new design. Systems previously certified on an aircraft model may be transferred to other aircraft models. Each system considered for certification by similarity needs to be assessed independently even if it may use equipment and installation techniques that have been the subject of a previous certification.

(b) The system used as the basis for certification by similarity must have been certified previously for HIRF on another aircraft model. Certification by similarity requires a comparison of both equipment and installation differences that could adversely effect HIRF susceptibility. An assessment of a new system installation should consider the differences that could affect the internal HIRF environment of the system and its wiring, such as the following:

1. The aircraft type, equipment locations, airframe construction, and apertures that could affect attenuation for the external HIRF environment;

2. The equipment interfaces, wiring, grounding, bonding, connectors, and wire-shielding practices; and

3. The line replaceable units that comprise the system.

(c) If the assessment finds only minimal differences between previously certified installations and the installation to be certified, similarity may be used as the basis for certification without the need for additional tests providing there are no unresolved in-service HIRF problems. If there is uncertainty about the effects of the differences, additional tests and analysis should be conducted as necessary and appropriate to resolve the open issues. The amount of testing to be undertaken should be commensurate with the degree of change identified between the immediate system and its application and those items tested previously. If significant differences are found, similarity should not be used as the basis for certification.

(3) Level B or Level C Systems. Certification by similarity often is more appropriate for level B or level C systems than for level A systems and can be achieved by demonstrating that the equipment is similar to equipment that has previously met the HIRF test levels appropriate to its assessed failure condition classification as defined in step 12.

n. Step 14 – Other Methods.

(1) Other methods for HIRF compliance verification include modeling, analysis, and combinations of any method given in the other steps. Comprehensive modeling and analysis for RF field coupling to the aircraft structure is an emerging technology; therefore, modeling and analysis alone currently are not adequate for showing HIRF compliance for level A systems and should be augmented by testing.

(2) Analytical models representative of the aircraft and transfer function characteristics of the equipment or system installation may be used in conjunction with supporting test data to provide HIRF compliance verification. Any data submitted should take into account the quality of the model and provide the model's assumed accuracy and the margins established by such an assessment. The margins should depend heavily on the quality of the data base used in the model. Significant testing, including aircraft level testing, may be required to support the submission. Models capable of providing detailed system performance assessments related to systems performing level A functions generally are not currently accepted, but accepted practices may develop in the future.

(3) In some situations, the steps outlined in this AC may not be suitable or new technologies may emerge that offer an alternative approach. In such cases, discussions with the FAA should be held early in the certification process.

o. Step 15 – HIRF Vulnerability.

(1) The primary intent of the HIRF vulnerability assessment should be to verify that all the functional requirements of the system are met when subjected to the internal HIRF environment generated as a result of the aircraft's or system's exposure to the applicable external HIRF environments. The pass/fail criteria defined in the test plan should be used for this assessment.

(2) HIRF susceptibilities that were not anticipated or defined in the test plan pass/fail criteria may be found during aircraft, system, or equipment tests. If so, the data collected during the HIRF compliance verification process should be used to determine the effect of the HIRF susceptibility on the aircraft systems and functions. The pass/fail criteria may be modified if the effects neither cause nor contribute to conditions that adversely affect the aircraft functions or systems, as applicable, in the HIRF

regulations. The applicant should provide to the FAA for approval an assessment of and supporting rationale for any modifications to the pass/fail criteria.

(3) If the level A system passed the required tests when exposed to HIRF environment I or III, as applicable, with no adverse effects, then additional testing in HIRF environment II is not required.

(4) The system safety assessment may show that the functions performed by the systems do not have the same failure condition classification throughout all phases of flight. Therefore, the HIRF environment appropriate to the sensitive phase of flight should be used for the HIRF vulnerability assessment.

(5) The HIRF vulnerability analysis documentation should include all observed effects, assumptions, and assessments to show compliance with the HIRF requirements.

(6) Tests for the HIRF environments above 18 GHz are not required if data and design analysis show the integrated system rig tests results satisfy the pass criteria from 12 GHz to 18 GHz, and the systems have no circuits that operate in the 18 GHz to 40 GHz frequency range.

(7) Certain RF receivers with antennas connected should not be expected to perform without effects during exposure to the HIRF environments, particularly in the RF receiver operating band. Because the definition of adverse effects and the RF response at particular portions of the spectrum depends on the RF receiver system function, refer to the individual RF receiver minimum performance standards for additional guidance. However, because many RF receiver minimum performance standards were prepared before implementation of HIRF requirements, the RF receiver pass/fail criteria should be coordinated with the FAA. Future modifications of the minimum performance standards should reflect HIRF performance requirements.

p. <u>Step 16 – Corrective Measures</u>. If the equipment or system fails to satisfy the HIRF vulnerability assessment of step 15, corrective action should be taken. Any changes or modifications to the equipment or system and/or its installation may generate the need for retesting. The relevant equipment or system qualification testing of RTCA/DO-160 and/or the aircraft testing, in whole or in part, may need to be repeated to satisfy the requirements of the HIRF compliance submission.

q. Step 17 – Certification. The applicant should submit the test results and compliance report to the cognizant FAA certification office for approval as part of the overall aircraft type certification or supplemental type certification process.

11. MAINTENANCE, PROTECTION ASSURANCE, AND MODIFICATIONS.

a. The minimum maintenance required to support HIRF certification should be identified in instructions for continued airworthiness as specified in §§ 23.1529, 25.1529, 27.1529, and 29.1529, as appropriate. When dedicated protection devices or specific techniques are required to provide the protection for an equipment or system installation, periodic maintenance, special tests, and HIRF protection assurance requirements or techniques should be defined to ensure protection integrity is not degraded in service.

b. The use of devices that may degrade over time because of corrosion, fretting, flexing cycles, or other causes should be avoided. Whenever possible, dedicated replacement times should be identified. Aircraft or system modifications should be assessed for the impact any changes will have on the HIRF protection level. This assessment should be based on analysis and/or measurement.

c. The techniques and time intervals for evaluating or monitoring the integrity of the equipment's or system's HIRF protection should be defined. Built-in test equipment, resistance measurements, continuity checks of the entire system, or other means should be identified to provide assurance of the system integrity. The User's Guide provides further information on these topics.

[Insert Appropriate Name]
[Insert Appropriate Title]

APPENDIX 1 – GENERIC TRANSFER FUNCTION/ATTENUATION CURVES

1. GENERIC TRANSFER FUNCTION CURVES.

a. Suitable transfer functions for calculating the BCI test levels are given in figures A-1 through A-5. These are derived generic transfer functions acquired by tests on a significant number of aircraft, with the test results processed to establish a 95 percent population probability.

b. The curves are normalized to a 1 V/m HIRF environment and may be multiplied linearly by the external HIRF environment to establish the BCI test level requirements in the frequency range up to 400 MHz.

c. These generic curves are for wiring bundles running within the airframe with no additional protection such as that provided by conduits or raceways. In the compliance submission, the added protection such measures provide should be demonstrated if a lower test level is considered more representative.

2. GENERIC ATTENUATION CURVES.

a. Figure A-6 shows the generic attenuation curves that can be used for predicting the internal HIRF environment at the location of the equipment over the frequency band 100 MHz to 18 GHz. This predicted internal HIRF environment then provides the test level for the radiated susceptibility test.

b. Guidance on the use of these curves is given below:

(1) CAT Y. This attenuation curve can be used when the equipment under consideration is located in very severe electromagnetic environments, defined as areas with unprotected nonconductive composite structures, areas where there is no guarantee of structural bonding, and other open areas where no shielding is provided. This attenuation curve also may be used when a broad range of installations is to be covered.

(2) Cat W. This attenuation curve can be used when the equipment under consideration is located in severe electromagnetic environments, defined as areas outside the fuselage such as wings, fairings, wheel wells, pylons, and control surfaces where minimal shielding is provided. This attenuation curve is not appropriate for equipment installations more appropriately described by the definition of a Cat Y location.

(3) Cat V. This attenuation curve can be used when the equipment under consideration is contained entirely within a moderate electromagnetic environment, defined as the fuselage of a metallic aircraft or composite aircraft demonstrating equivalent shielding effectiveness. Examples of such an environment are avionics bays not enclosed by bulkheads, cockpit areas, and locations with large apertures, such as doors without EMI gaskets, windows, and access panels. Current-carrying conductors in this environment, such as hydraulic tubing, control cables, wire bundles, and metal wire trays, are not necessarily electrically grounded at bulkheads. This attenuation curve is not appropriate for equipment installations more appropriately described by the CAT W and CAT Y locations.

(4) CAT U. This attenuation curve can be used when the equipment under consideration is contained entirely within a partially protected environment, defined as the fuselage of a metallic aircraft or composite aircraft demonstrating equivalent shielding effectiveness. Wire bundles in this environment passing through bulkheads should have shields terminated at the bulkhead connector. Wire bundles should be installed close to the ground plane and take advantage of other inherent shielding characteristics provided by metallic structures. Current-carrying conductors, such as hydraulic tubing, cables, and metal wire trays should be grounded electrically at all bulkheads. This attenuation curve is not appropriate for equipment installations more appropriately described by the definition of CAT V, W, and Y locations.

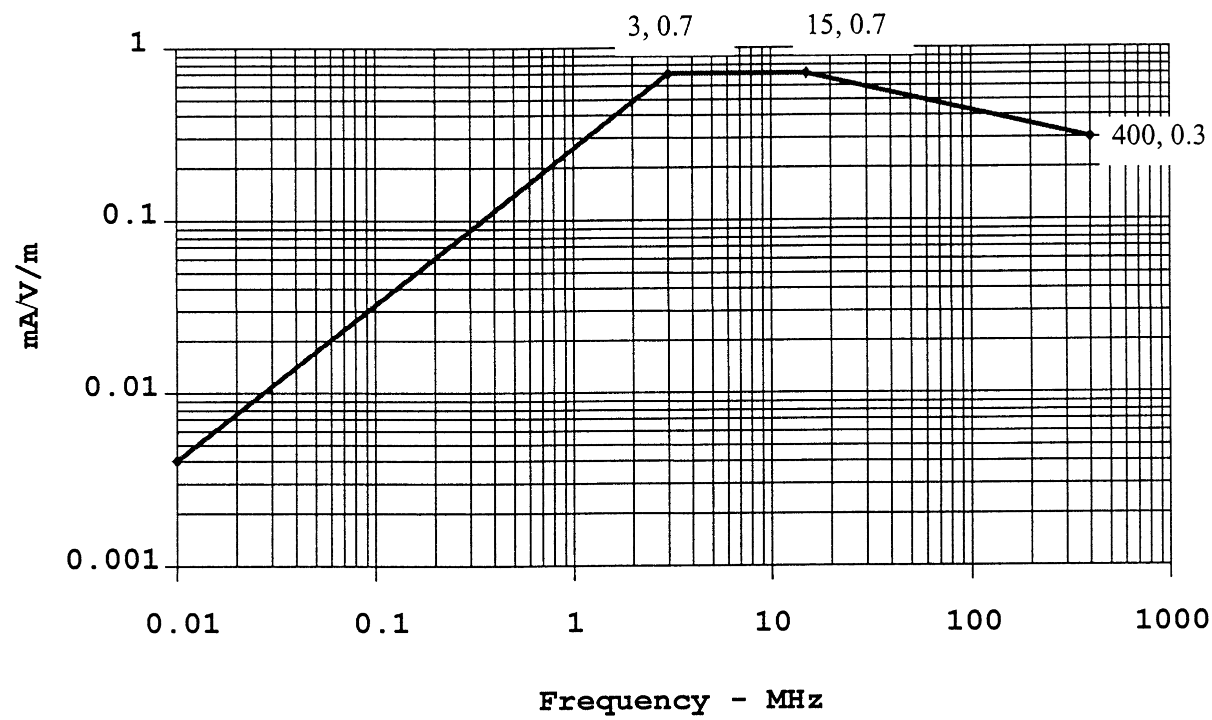
(5) CAT T. This attenuation curve can be used when the equipment under consideration, all interfaces to and from equipment, and the wire bundles are contained entirely within a well-protected environment, defined as an electromagnetically enclosed area. This attenuation curve is not appropriate for equipment installations more appropriately described by the definitions of CAT U, V, W, and Y locations.

c. Different attenuation curves may be appropriate for different frequency ranges. For example, CAT Y may be used for the frequency range of 100 MHz to 400 MHz, Cat W for the frequency range of 400 MHz to 1 GHz, and CAT V for the frequency range of 1 GHz to 18 GHz.

d. Airframe manufacturers can produce their own generic transfer function and attenuation curves based on measurements on their aircraft models and use these in their compliance submission in place of the generic curves specified in this appendix. This would be advantageous because they will provide a more accurate reflection of the true internal environment for their aircraft.

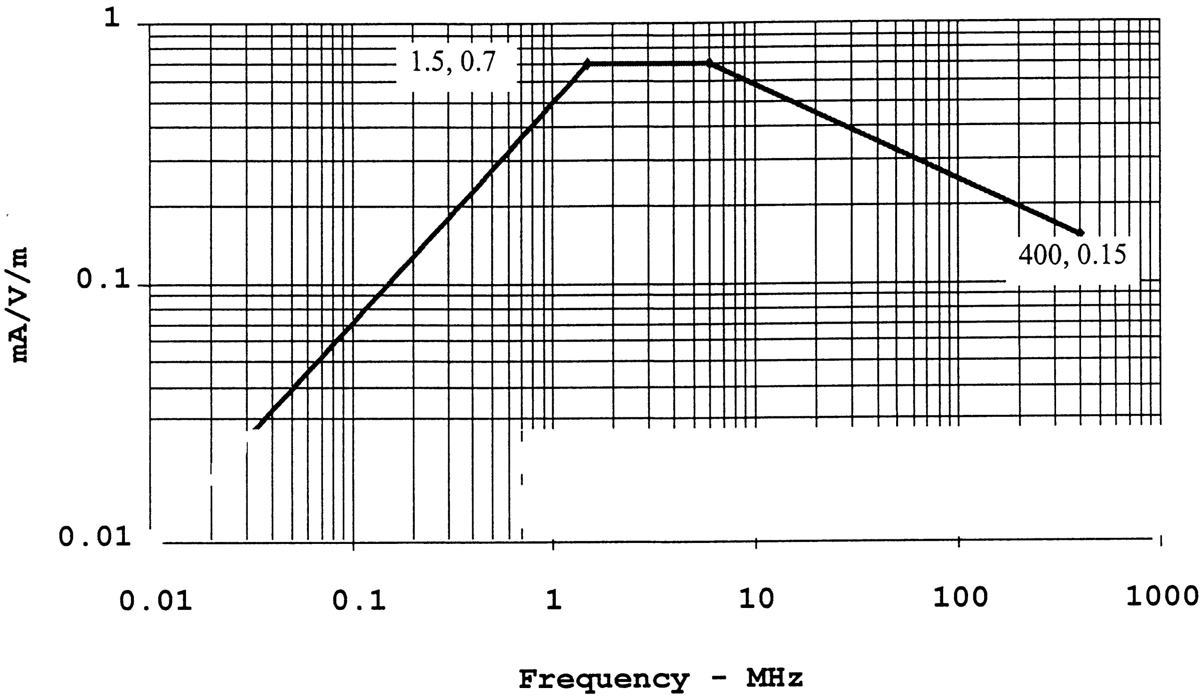
e. The User's Guide should be consulted for details on the use of generic curves.

FIGURE A-1 — Generic Transfer Function - Airplane



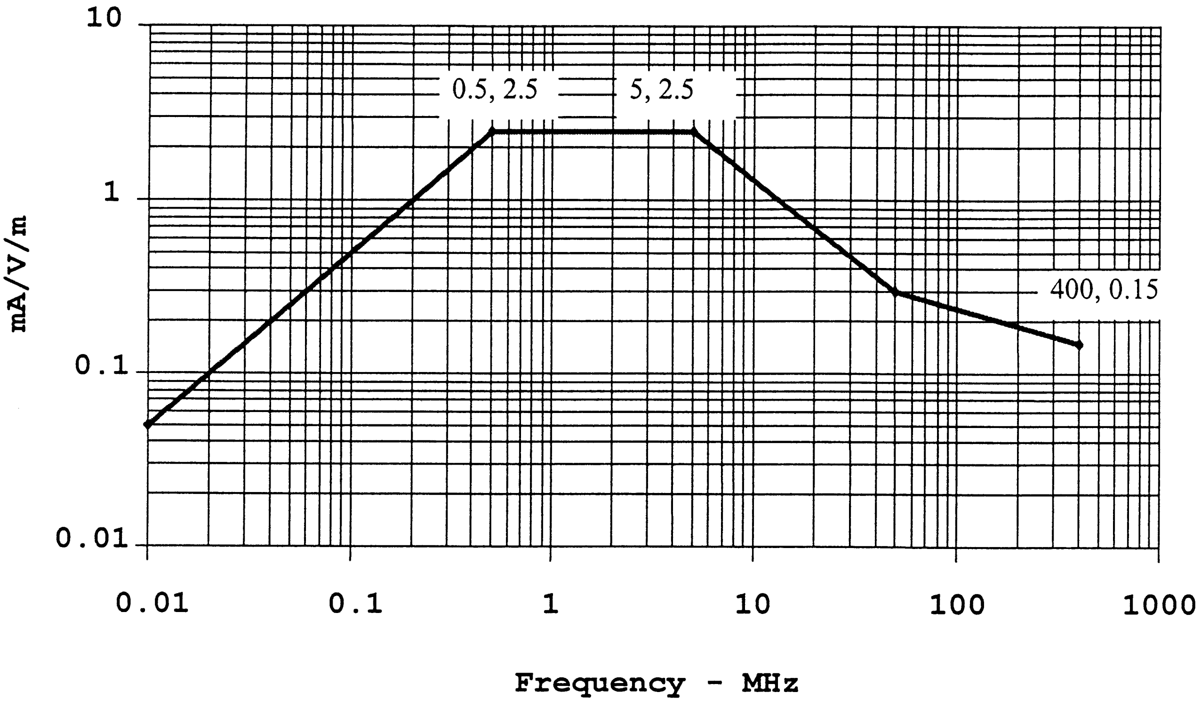
Generic transfer function curve normalized to 1 V/m for an airplane with a fuselage length of <25m.

FIGURE A-2 — Generic Transfer Function - Airplane



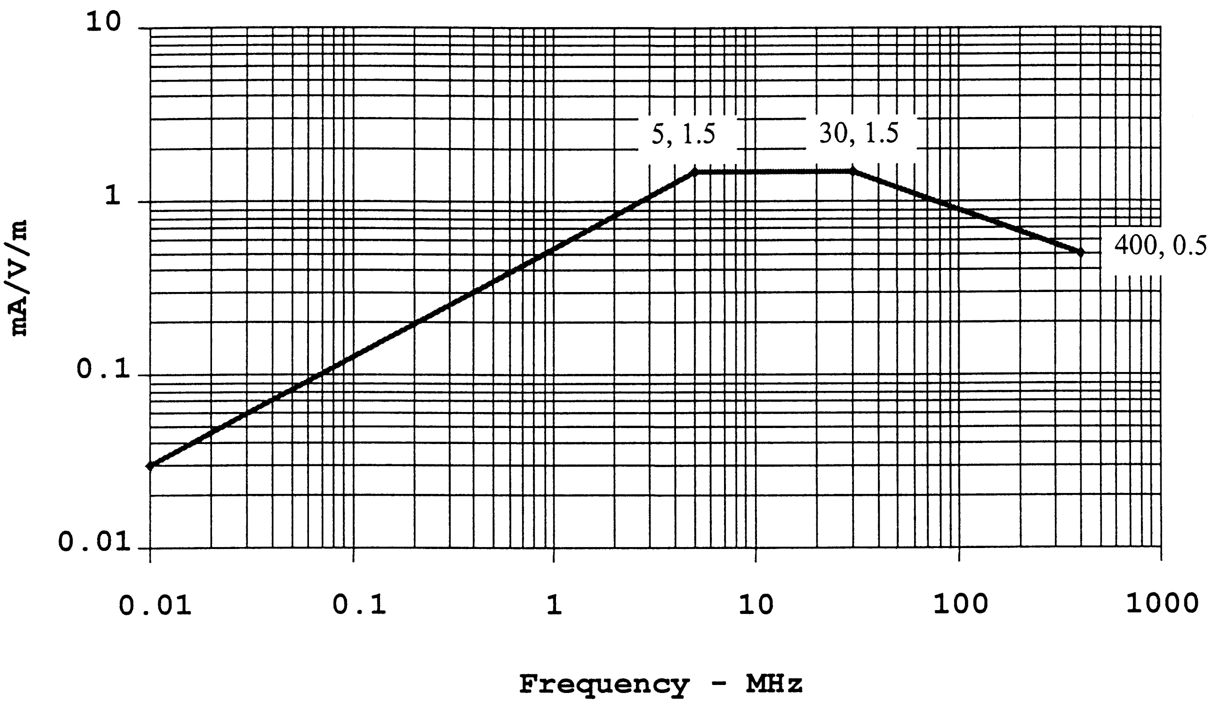
Generic transfer function curve normalized to 1 V/m for an airplane with a fuselage length of >25m and <50m.

FIGURE A-3 — Generic Transfer Function - Airplane



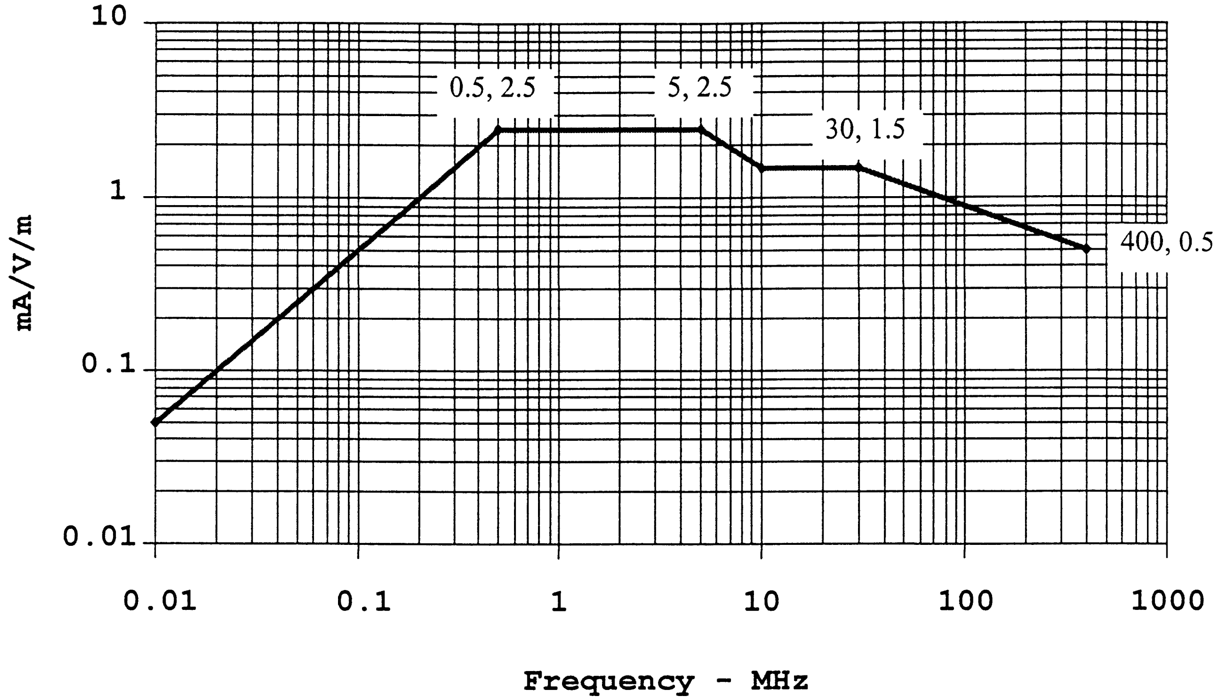
Generic transfer function curve normalized to 1 V/m for an airplane with a fuselage length of >50m.

FIGURE A-4 — Generic Transfer Function - Rotorcraft



Generic transfer function curve normalized to 1 V/m for a rotorcraft.

FIGURE A-5 — Generic Transfer Function - All Aircraft



Generic transfer function curve normalized to 1 V/m for all aircraft.

FIGURE A-6 — GENERIC ATTENUATION CURVES — All Aircraft